

Characterization of Metrology Tools and Optical Components for HVM EUV sources

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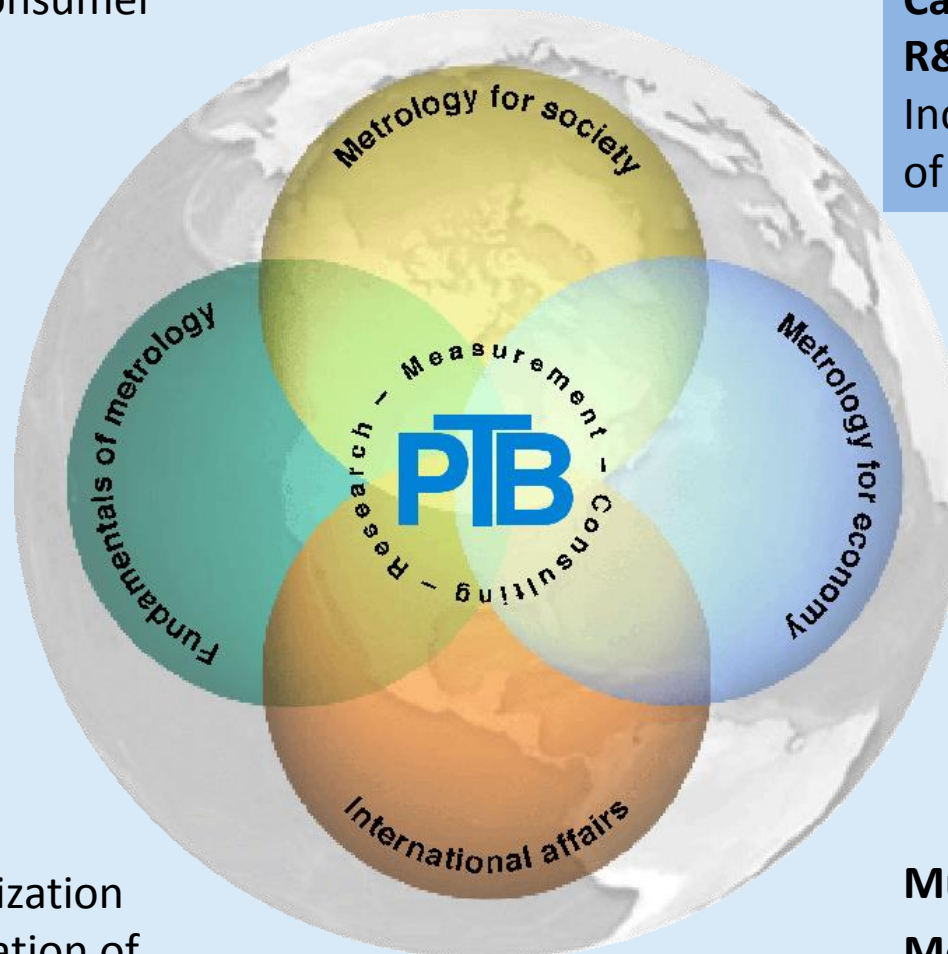
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- PTB facilities at Adlershof
- Detector calibration schemes
- Detector calibration examples
- Mirror and optics characterization
- Example: EUV LPP collector
- Options for polarization resolved measurements
- Summary and conclusions

Legal tasks Consumer protection

Calibrations and tests / R&D cooperations
Increasing the efficiency of economy

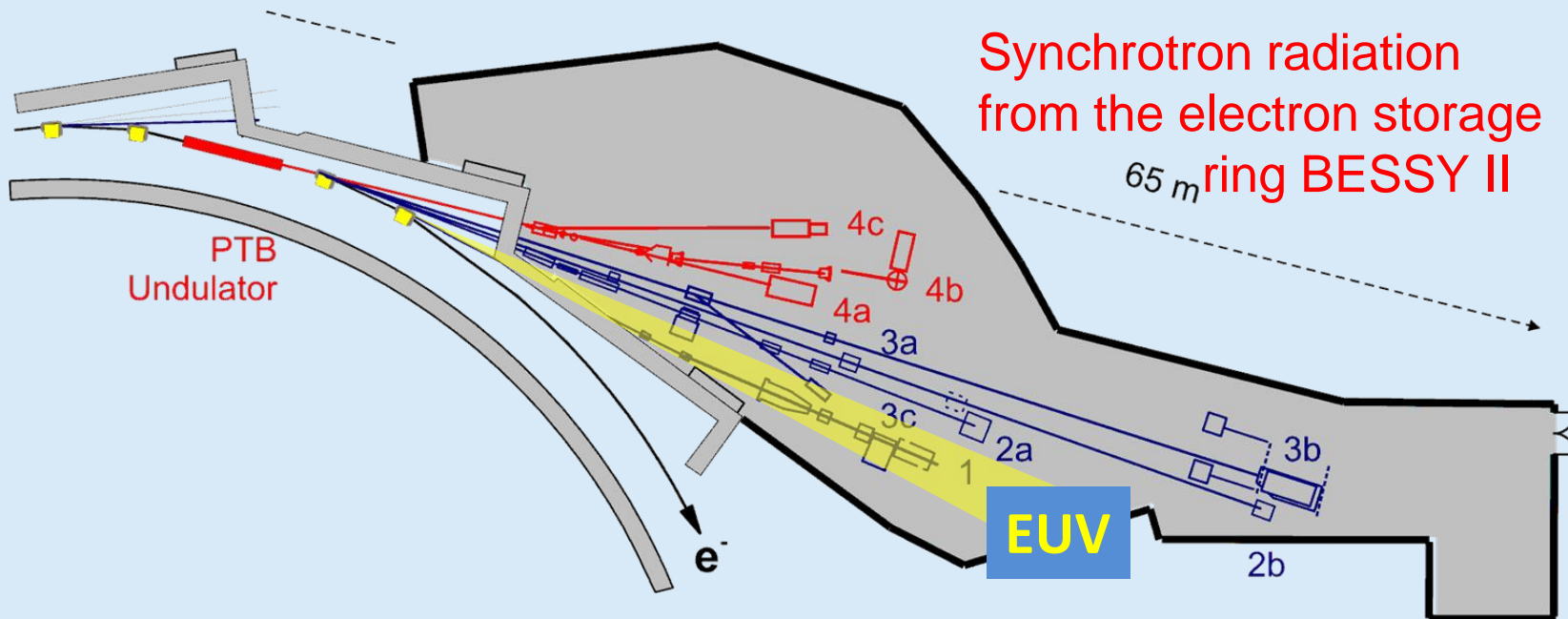


Fundamental research Realization and dissemination of the SI units

Mutual recognition agreement
Meter convention
Unification of metrology

PTB laboratories in Adlershof





**1 plane grating monochromator SX700
30 nm to 0.7 nm**

2a four-crystal monochromator
0.7 nm to 0.1 nm

2b X-ray pencil beam facility (XPBF),
astrophysics optics characterization

3a undispersed bending magnet radiation

3b normal incidence monochromator
(source calibration)

3c deflected undispersed bending magnet
radiation, EUV irradiation test station

4a undispersed undulator radiation
Compton backscattering

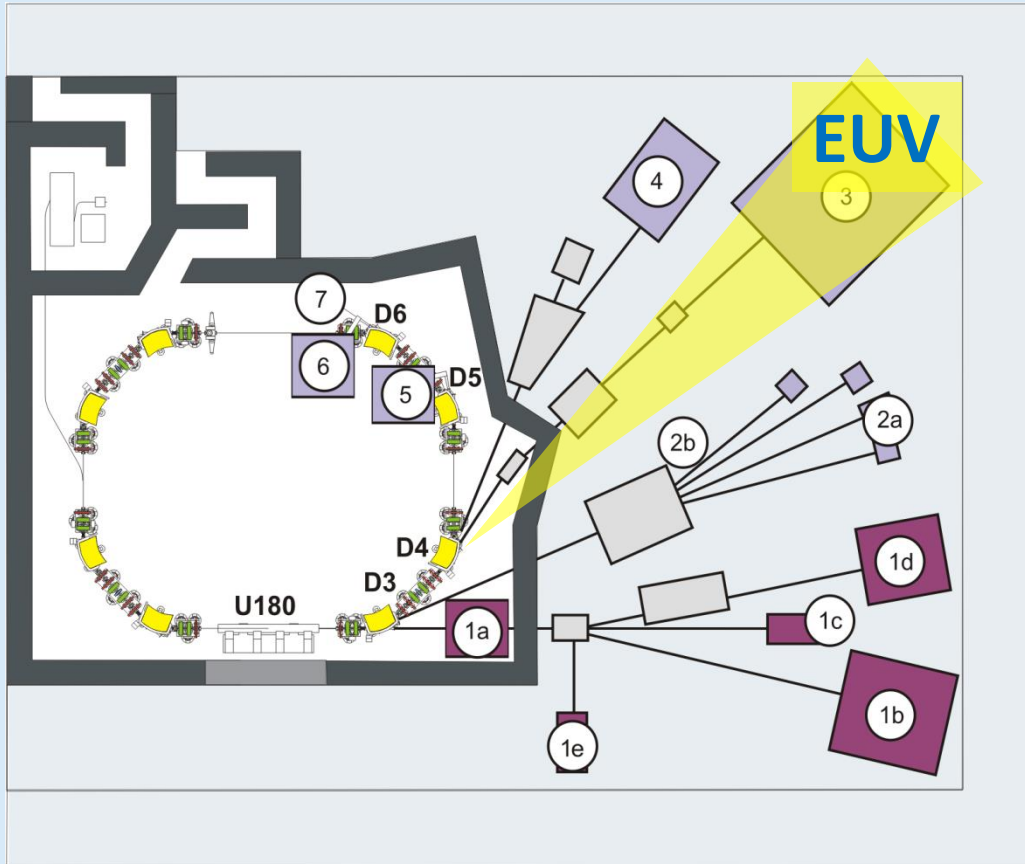
4b plane grating monochromator (PGM)
at undulator, 30 nm to 0.65 nm

4c deflected undispersed undulator radiation
EUVL metrology test station

PTB laboratories in Adlershof



Experimental stations at the MLS



28.08.2013

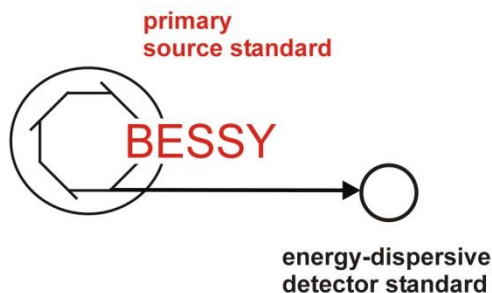
Installation of the EUV reflectometer
at the MLS EUV beamline

Synchrotron radiation beamlines operating
from the THz to EUV spectral regime

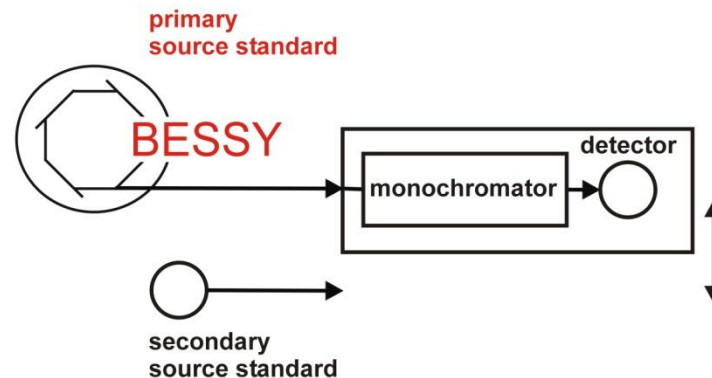
3:	EUV,	5 – 50 nm
4:	UV/VUV,	40-400 nm
5,6:	IR, THz	1 – 1000 μm

Source-based radiometry

(a) calibration of energy-dispersive detectors

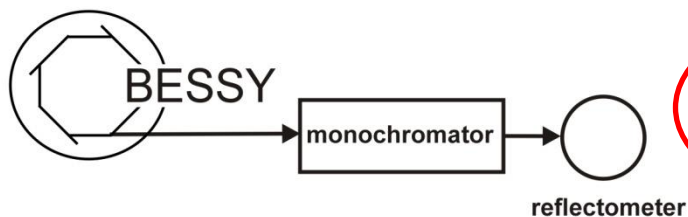


(b) calibration of radiation sources

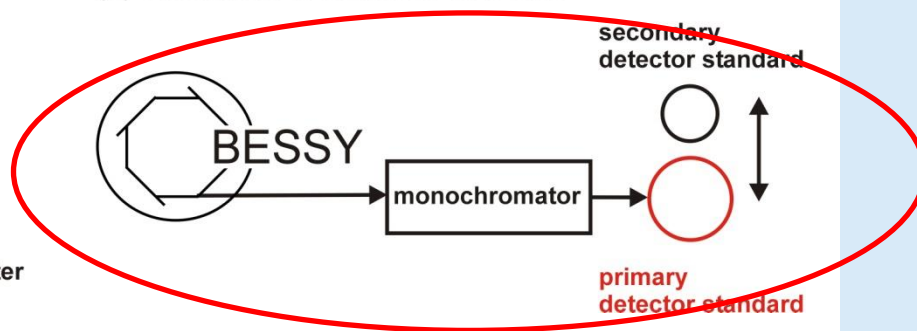


Detector-based radiometry

(c) reflectometry

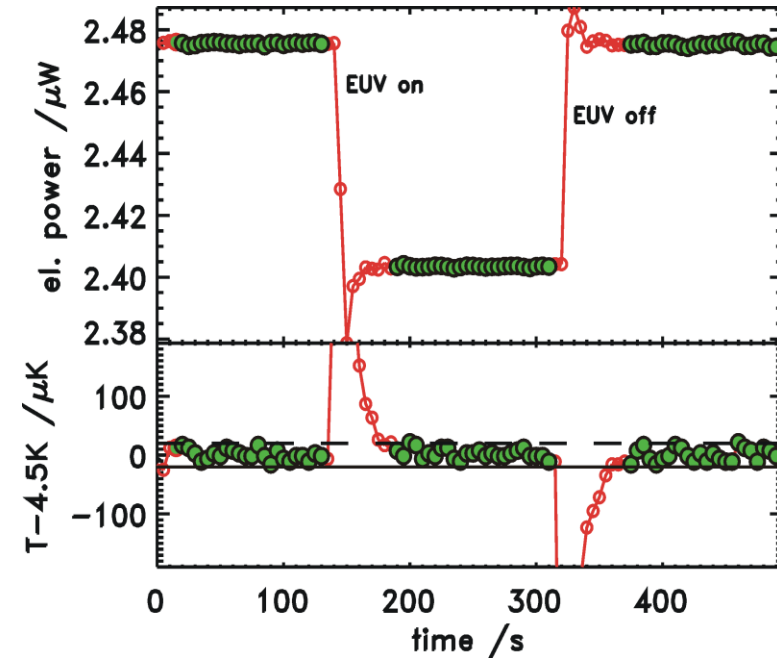
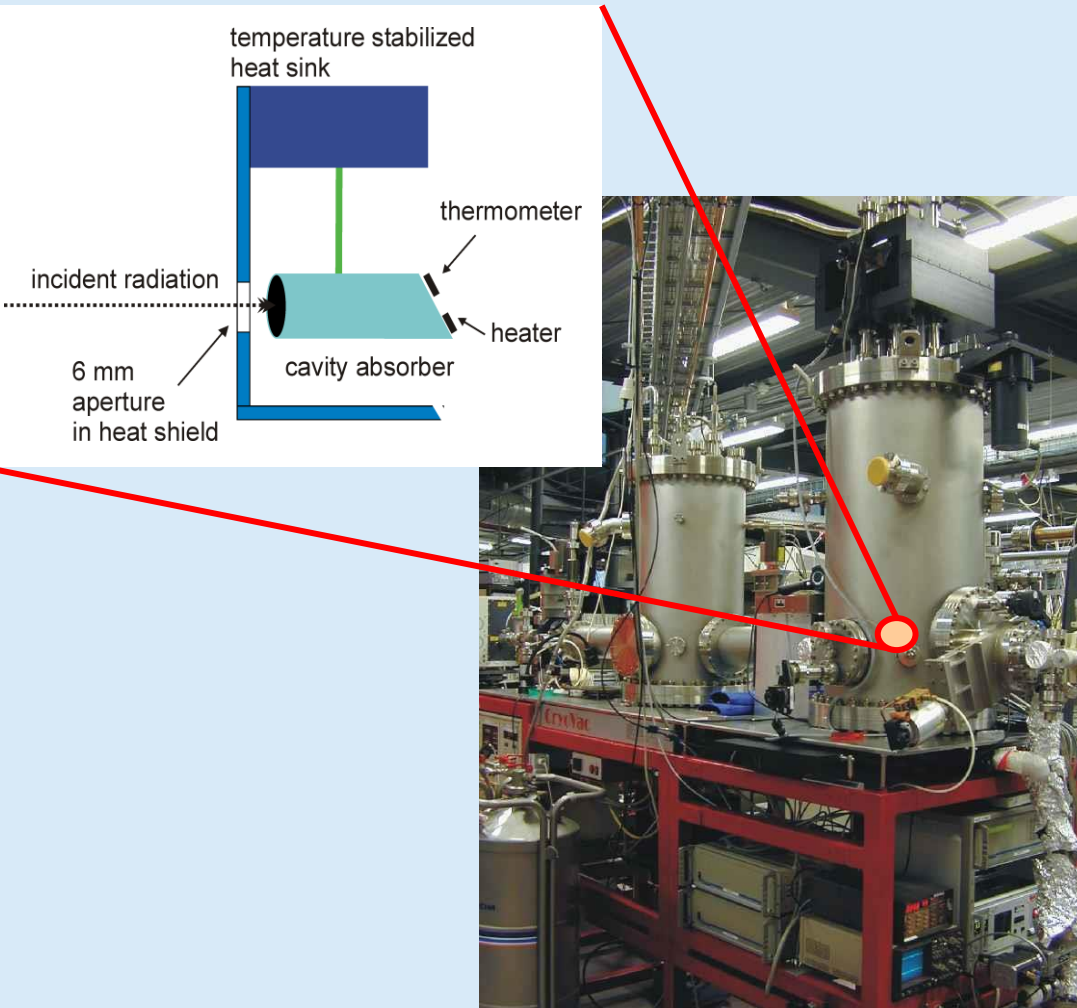


(d) calibration of radiation detectors

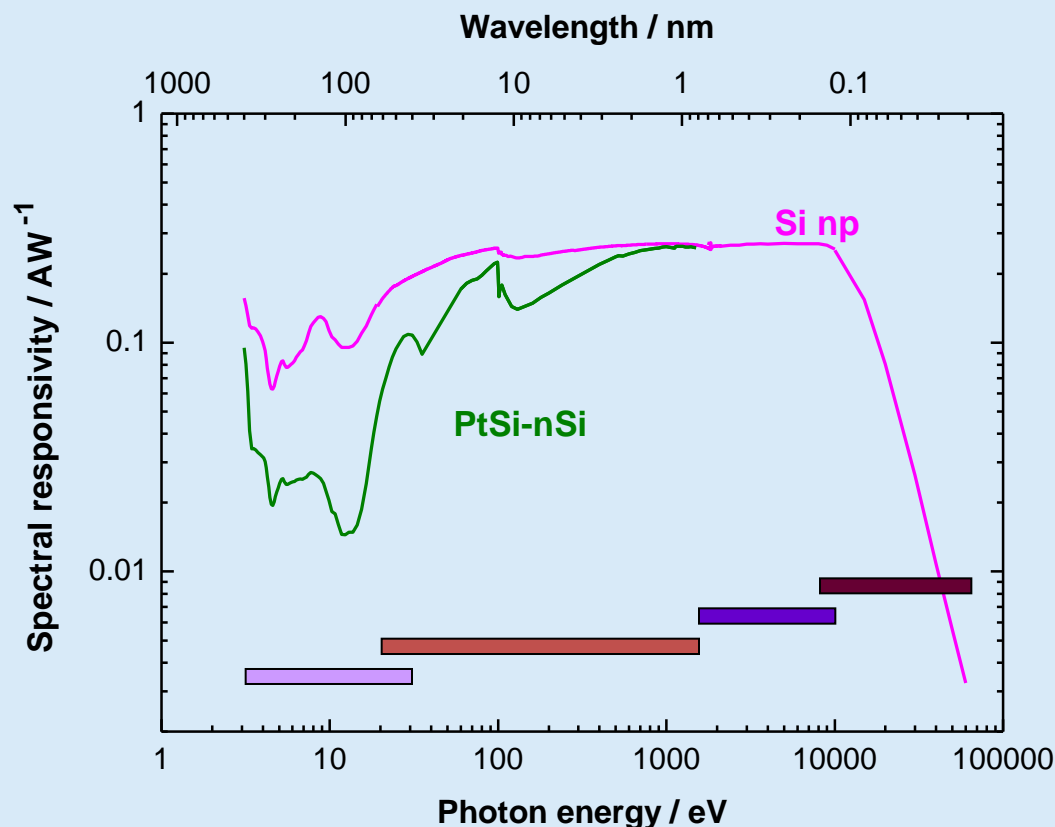


Detector calibration

Cryogenic Electrical Substitution Radiometer



Calibration of photodetectors

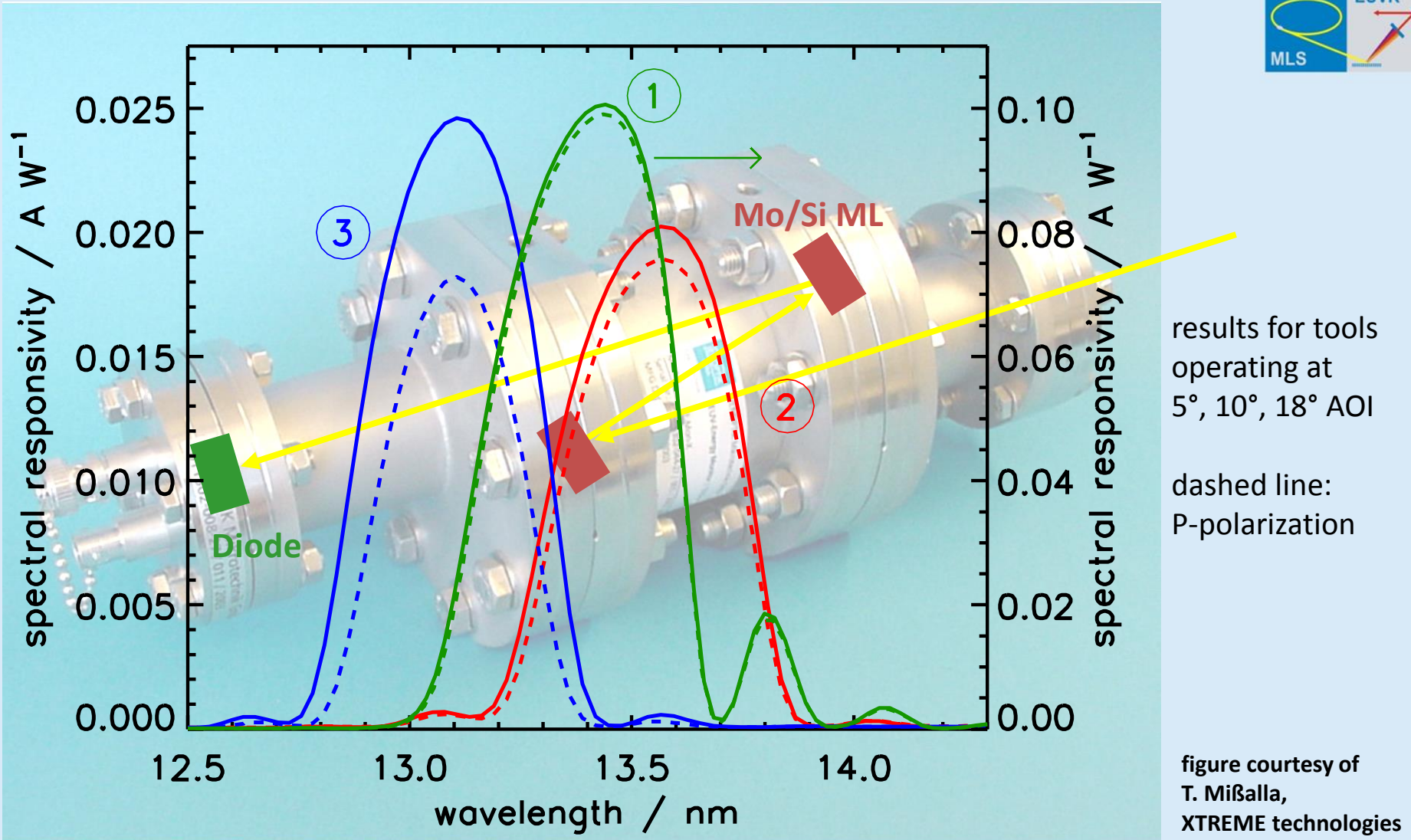


typically:
semiconductor photodiodes,
type depending from energy range due to

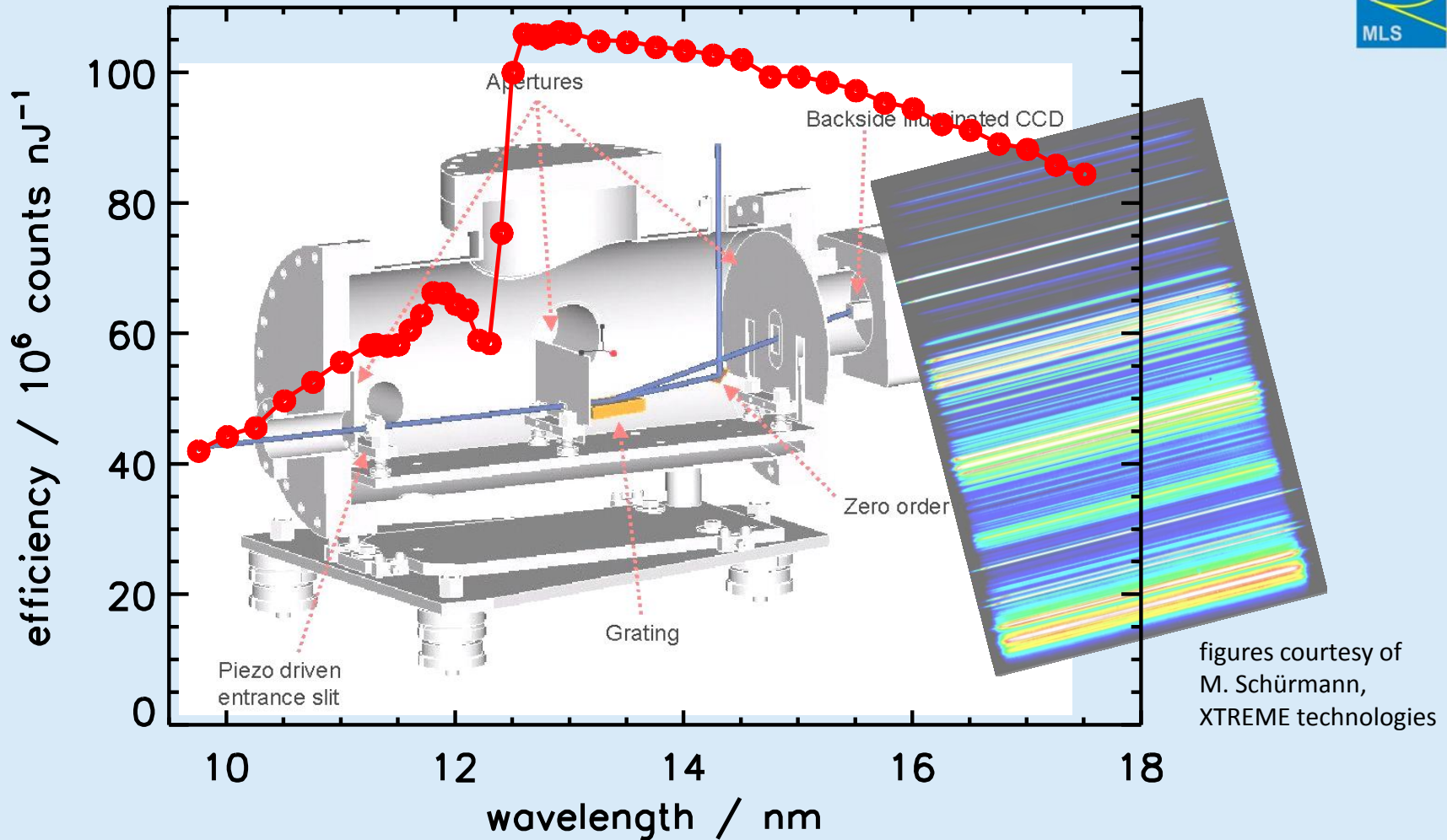
- stability
- linearity
- spatial uniformity

Relative standard uncertainty of
detector calibration: < 1.2 % ... 0.3 %

Application: EUV power meters



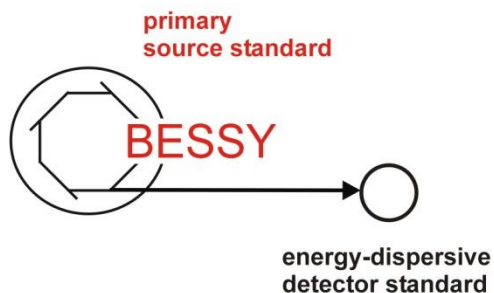
Application: EUV spectrometers



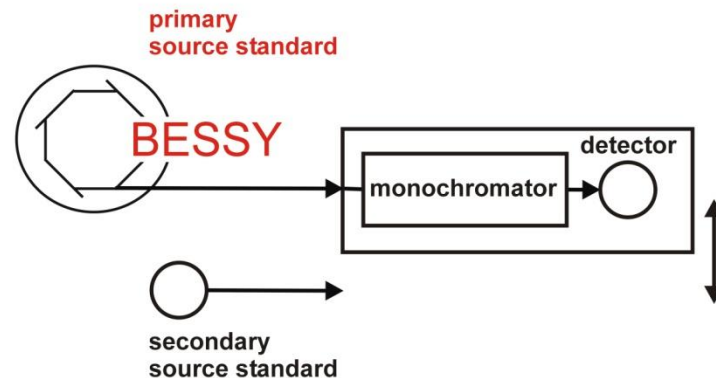
Measured efficiency of a flat-field grating spectrograph

Source-based radiometry

(a) calibration of energy-dispersive detectors

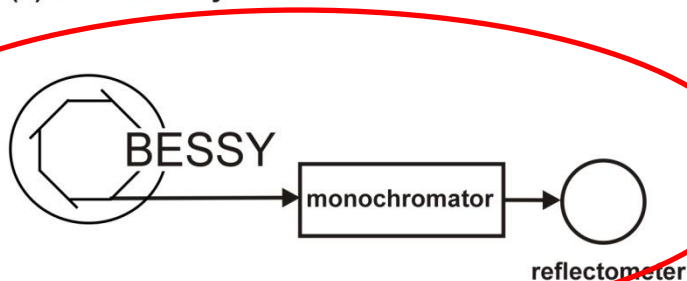


(b) calibration of radiation sources

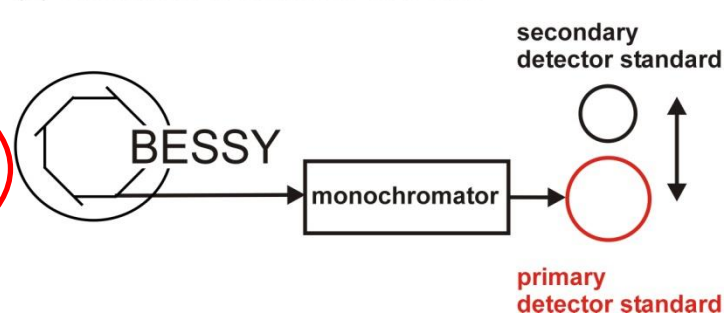


Detector-based radiometry

(c) reflectometry



(d) calibration of radiation detectors



Optics for EUV sources

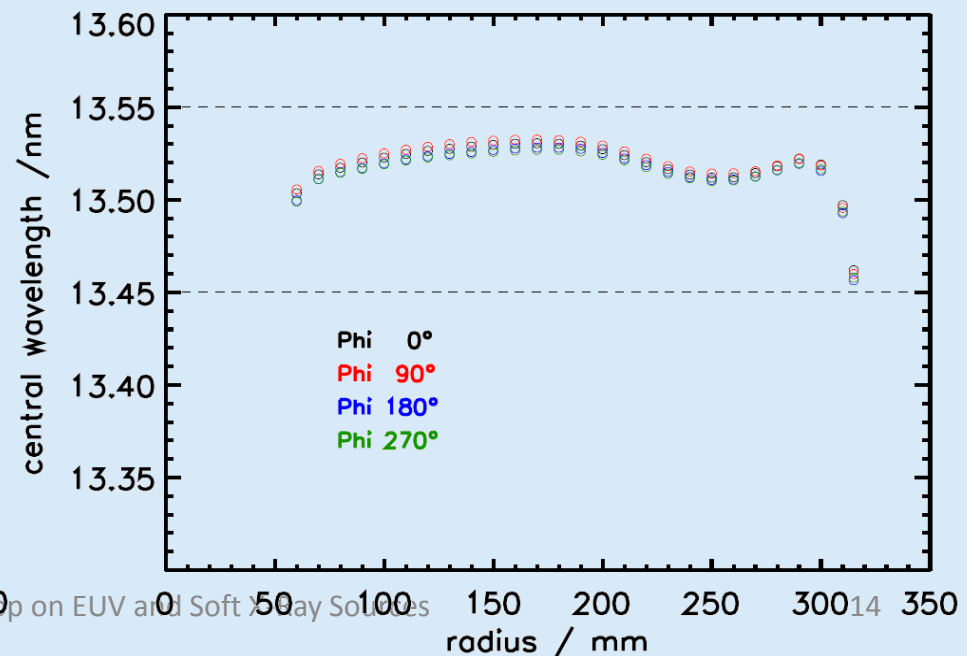
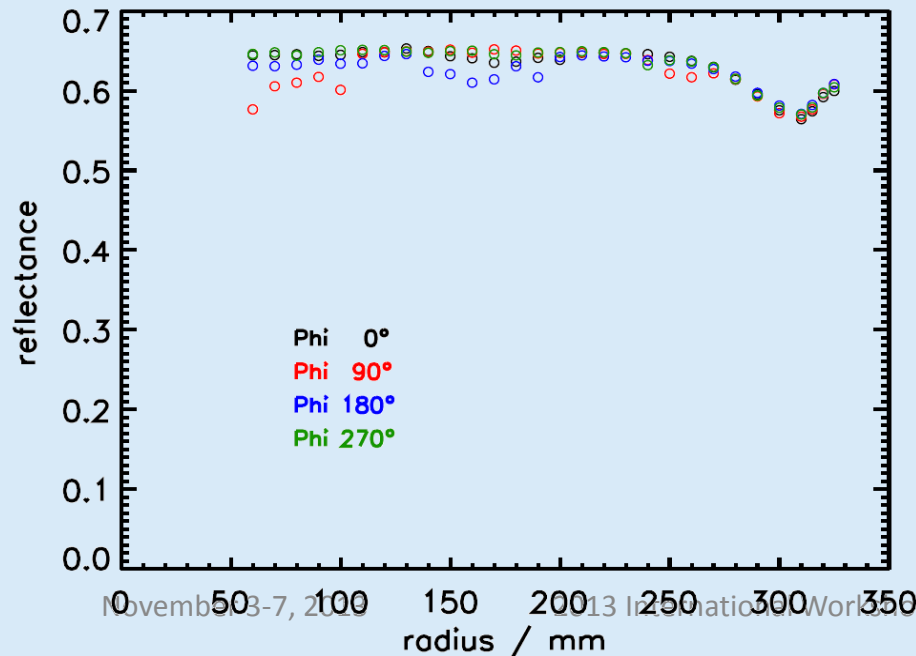
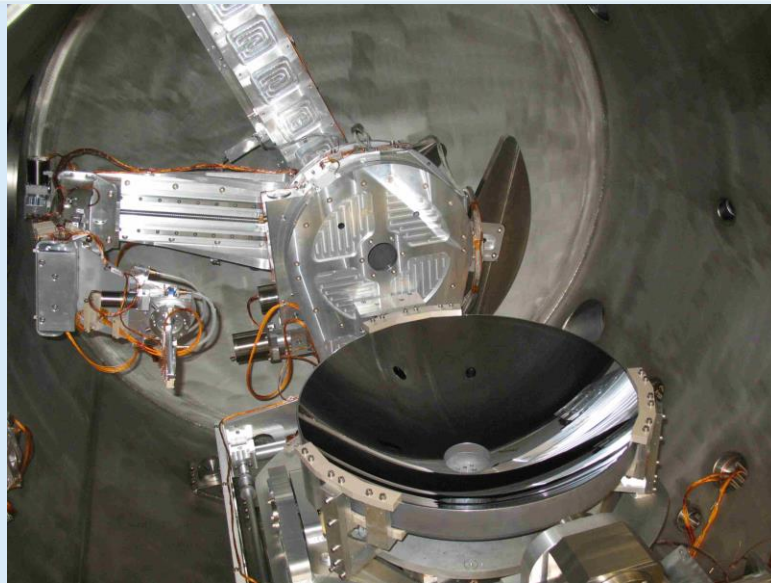
5 sr collector, 670 mm outer diameter design

CYMER®



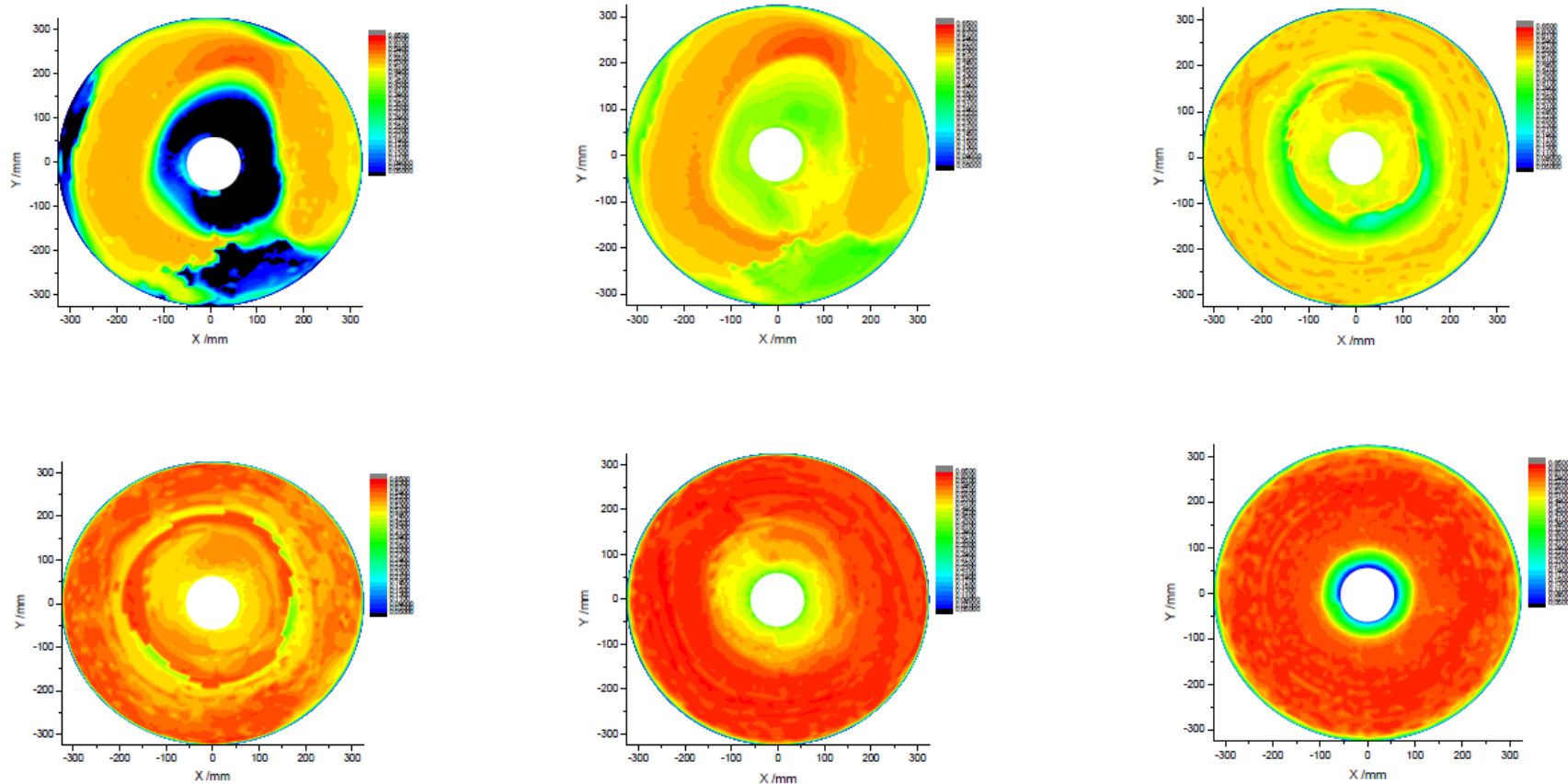
coating Fraunhofer Institut Angewandte Optik und Feinmechanik

mounted for measurements at PTB

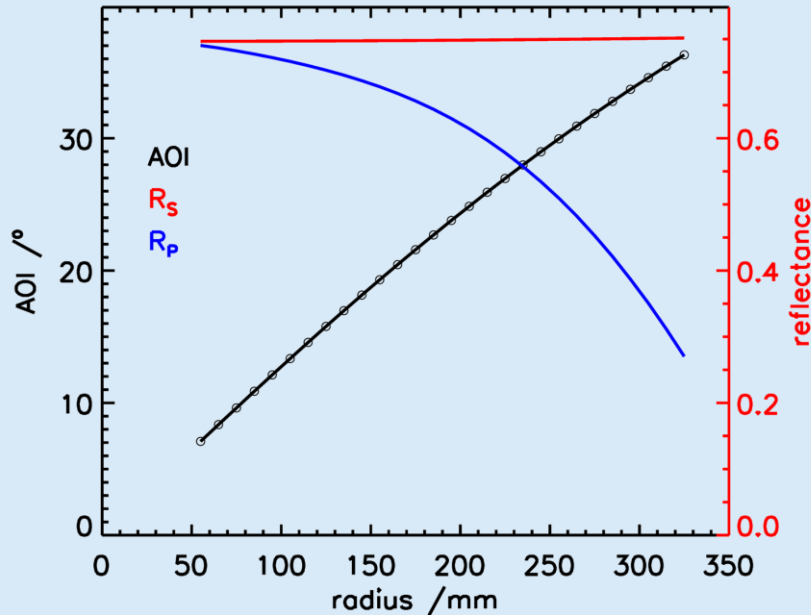


Full spatial mapping of collectors

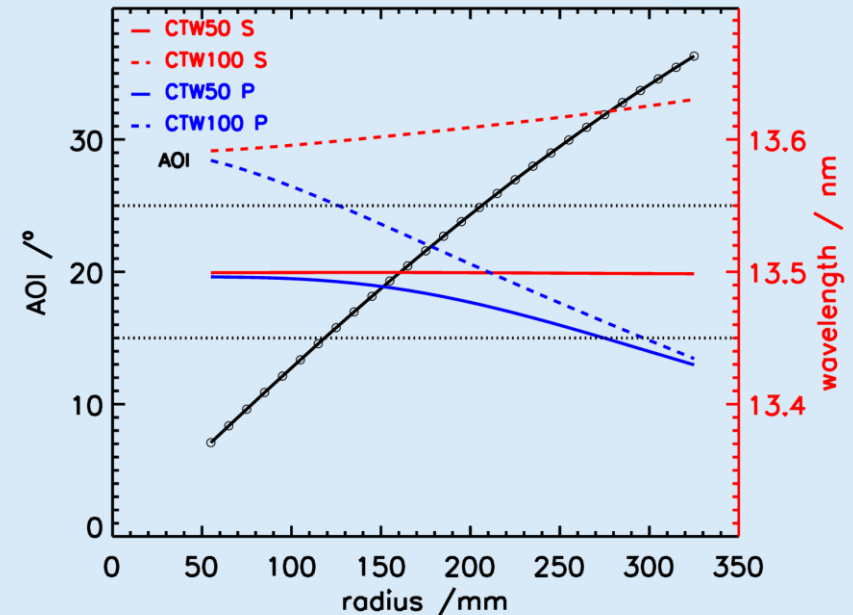
EUV reflectance mappings at different stages of refurbishment



High NA Optics - Polarization



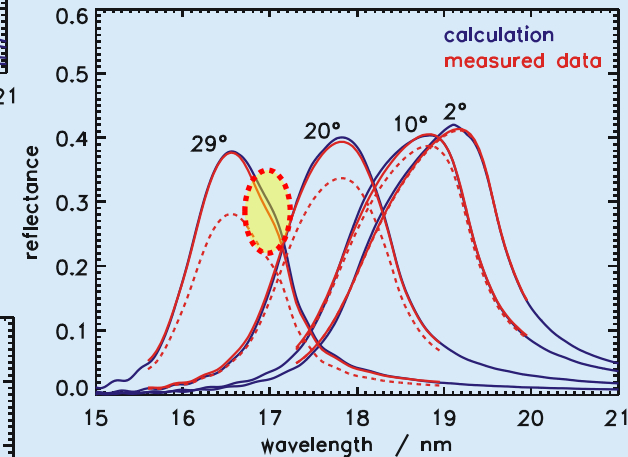
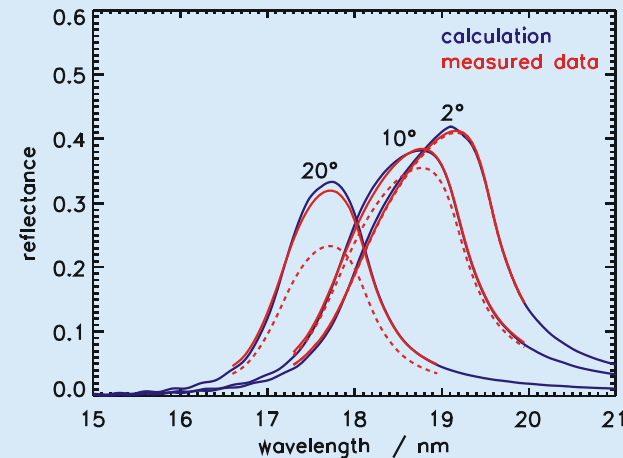
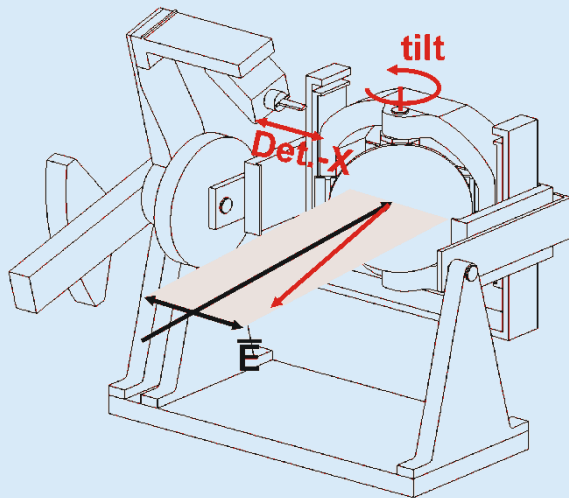
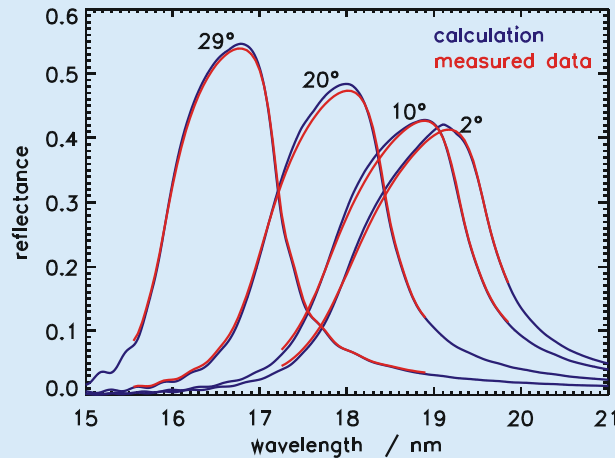
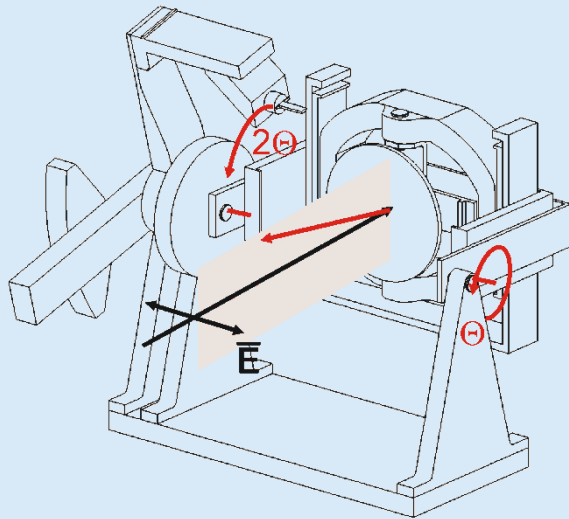
calculated ideal ML model
=> well known reduction of R_p



calculated ideal ML model
=> complex behavior of spectral shape

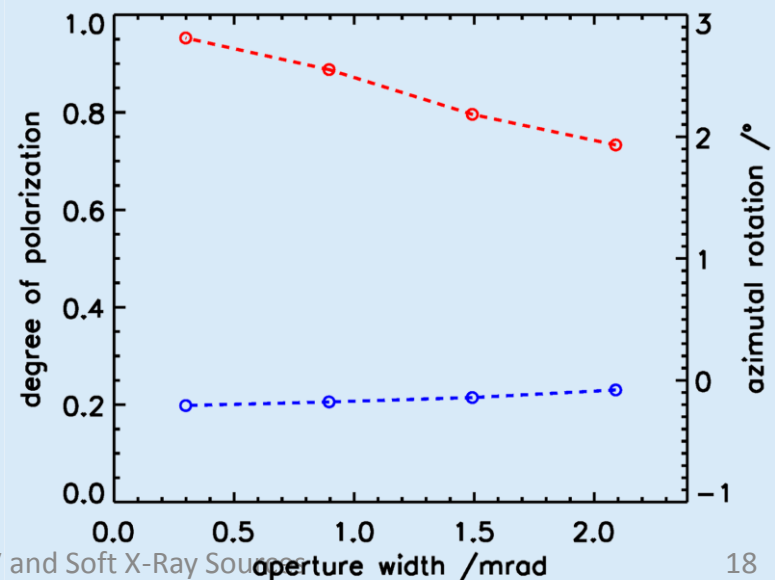
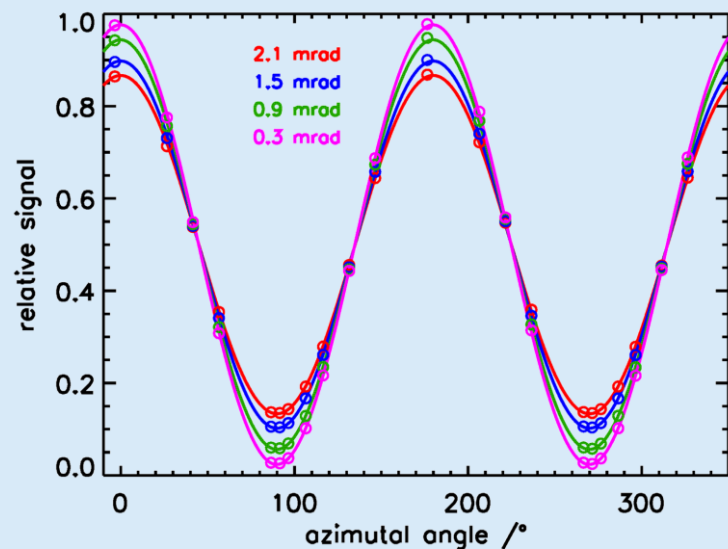
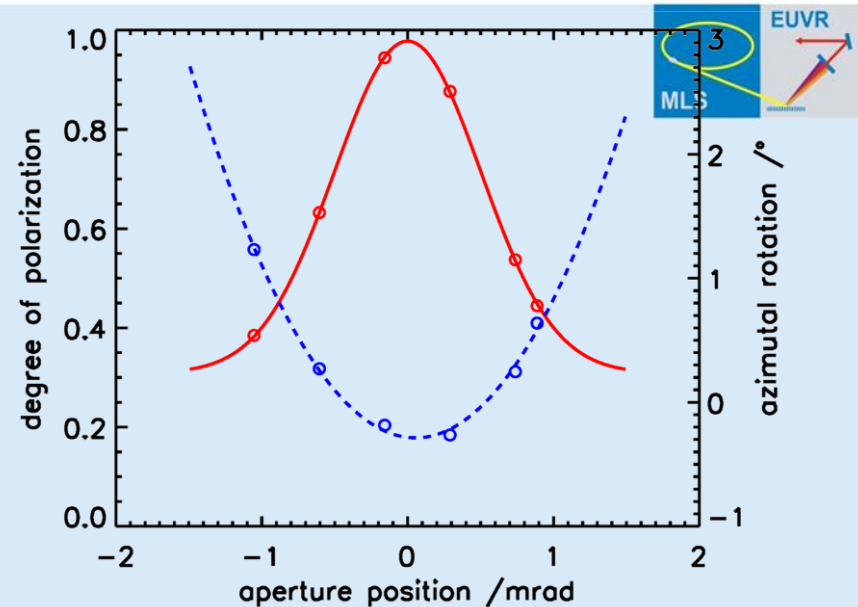
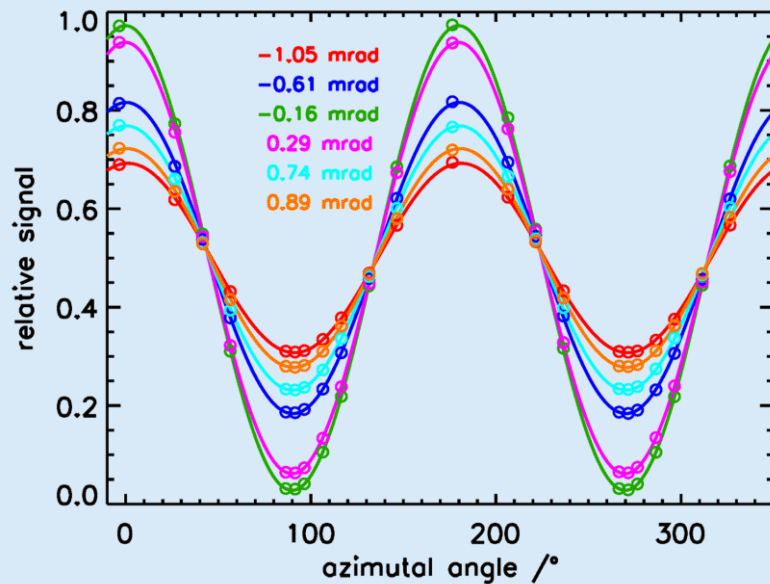
=> more measurements needed

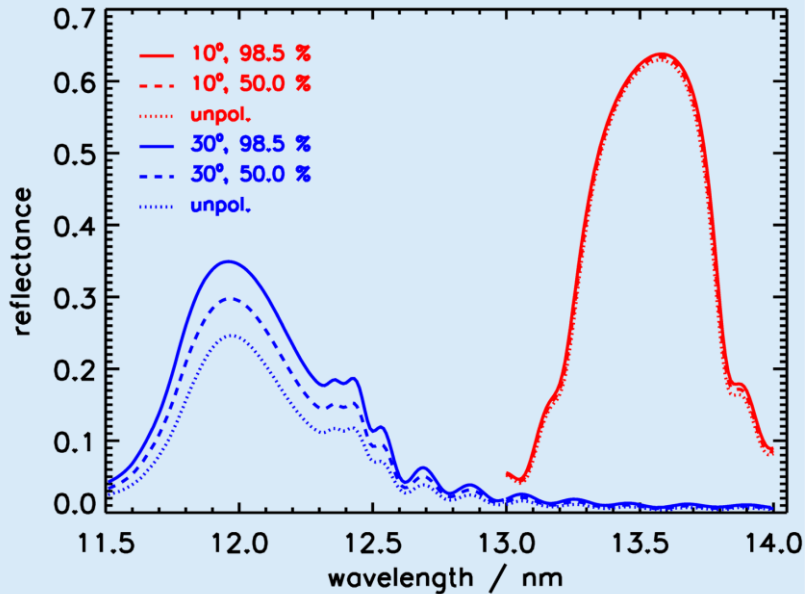
Previous capabilities



- only limited angular range
- not for large samples
- correction for detector responsivity needed

Polarization at the MLS EUV beamline





only beamline aperture changes
=> no change in beam position and size
at sample
=> correct AOI at detector

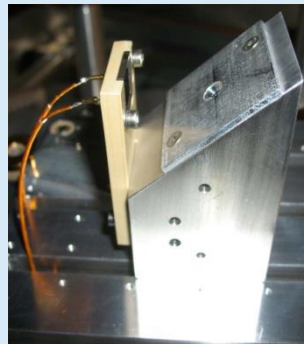
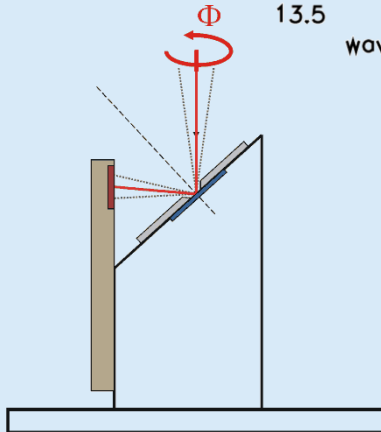
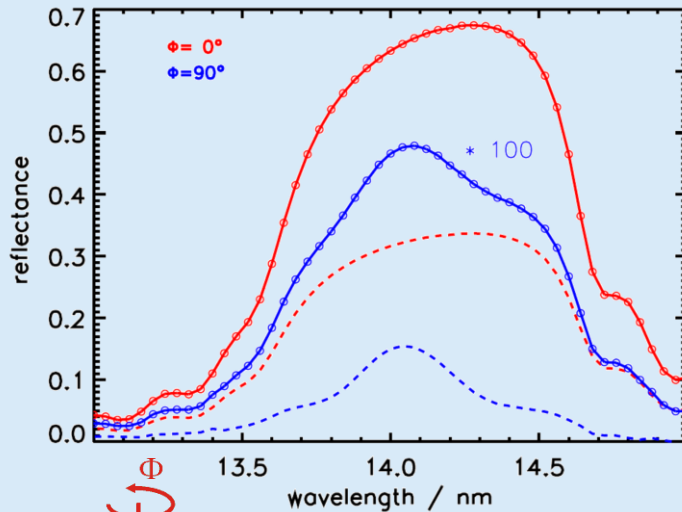
50% linear polarization allows for reliable
extrapolation for unpolarized radiation.

EUV reflectometer can accommodate
full size optics

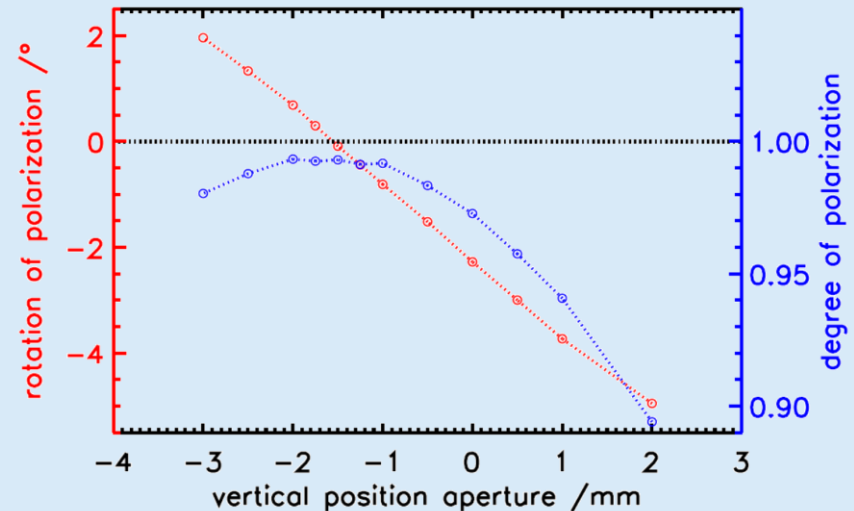
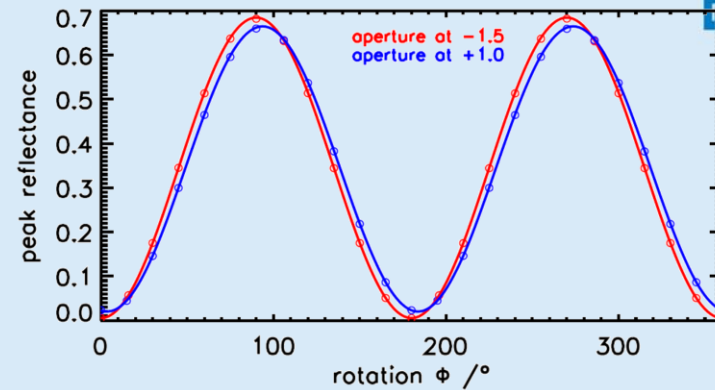
reflectance of an EUV multilayer mirror
polarization varied by moving the entrance
aperture of the beamline

Soft X-ray radiometry beamline

SX700: High degree of linear polarization

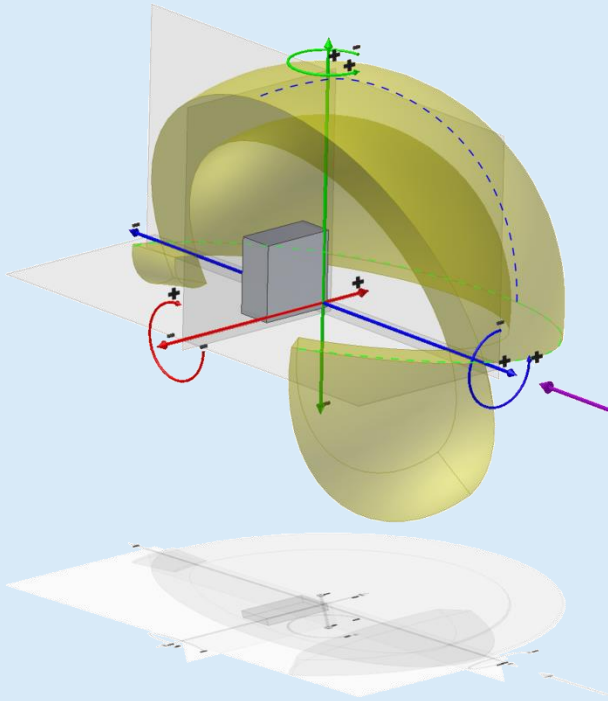


Polarimeter: multilayer at Brewster angle with photodiode for detection of the reflected light. The mount is rotated around the incident beam direction using the Φ axis of the reflectometer.



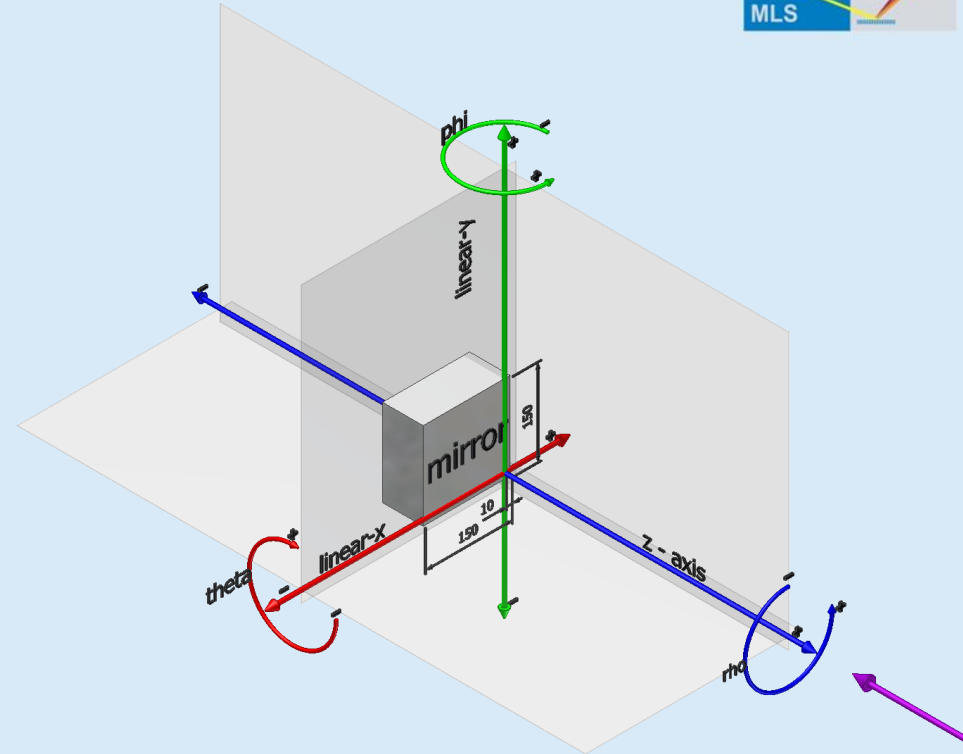
Degree of polarization and main axis orientation as function of entrance aperture position.

New EUV-Ellipso-Scatterometer



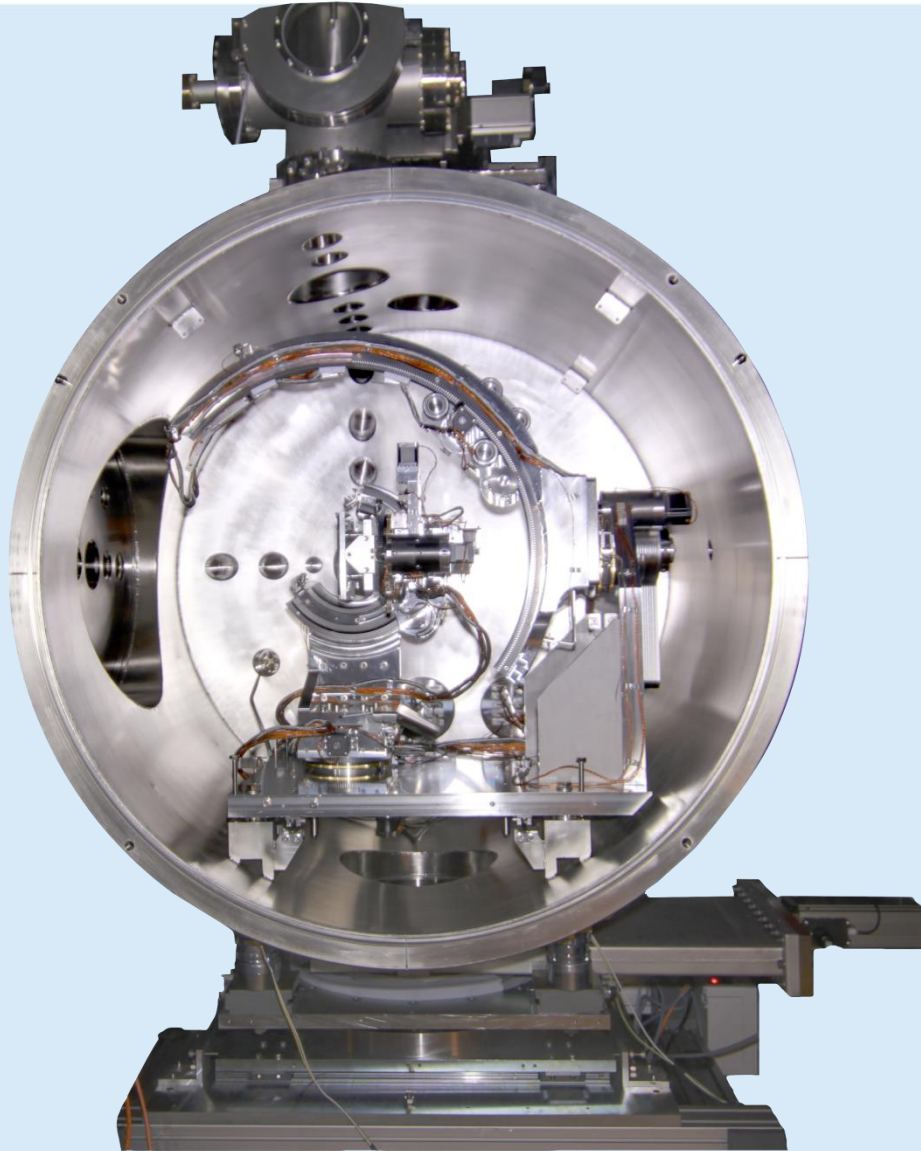
full 90° sample rotation,
full $\frac{1}{4}$ sphere detector movement,
sufficient space for complex detectors

2 axes
2 axes



sample manipulator for 6" substrates
max. sample size: 190 x 190 x 70
5 kg

New EUV-Ellipso-Scatterometer



Detector

azimutal	-10° to 100°	0.0002°
polar	-20° to 190°	0.0002°
flip	-179° to 179°	0.01°

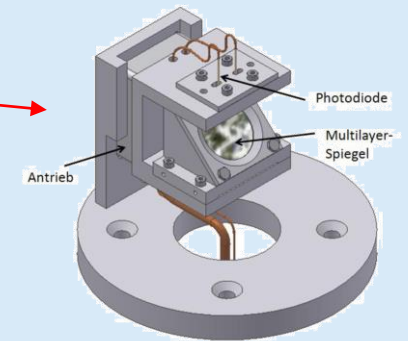
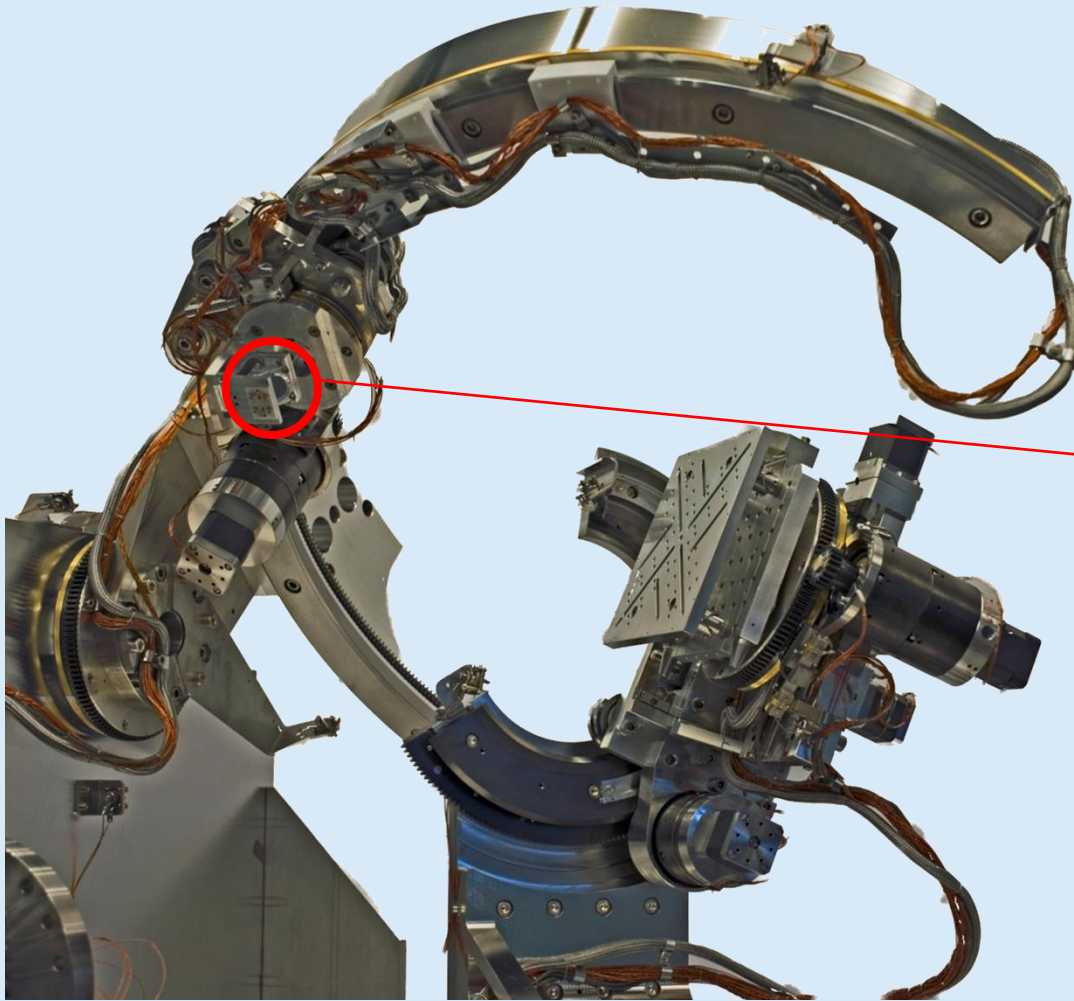
Sample

X	-10 to 90 mm	0.5 μm
Y	-10 to 90 mm	0.5 μm
Z	0 to 25 mm	0.5 μm
rot.-X	-30° to 100°	0.0002°
rot.-Y	-30° to 100°	0.0002°
rot.-Z	-179° to 179°	0.0002°

sample size: 190 x 190 x 70
weight: up to 5 kg

no lubricants used
(no organic contaminants)

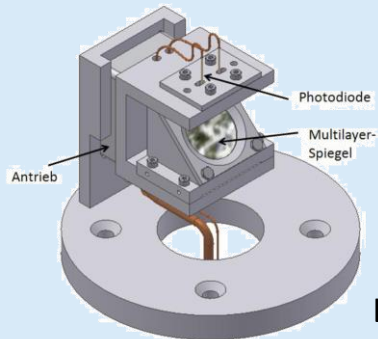
EUV-Ellipso-Scatterometer



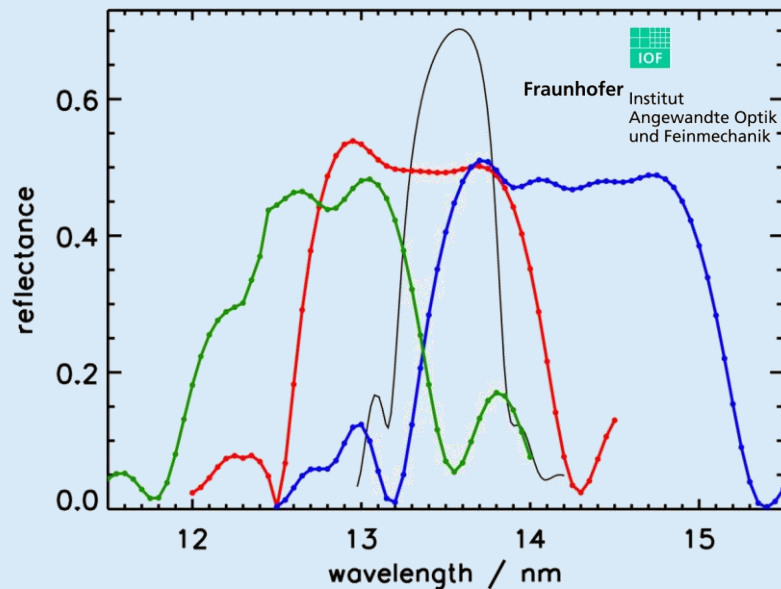
Linear polarization analyzer

sample and detector stages of the Ellisometer

EUV-Ellipso-Scatterometer



Linear polarization analyzer

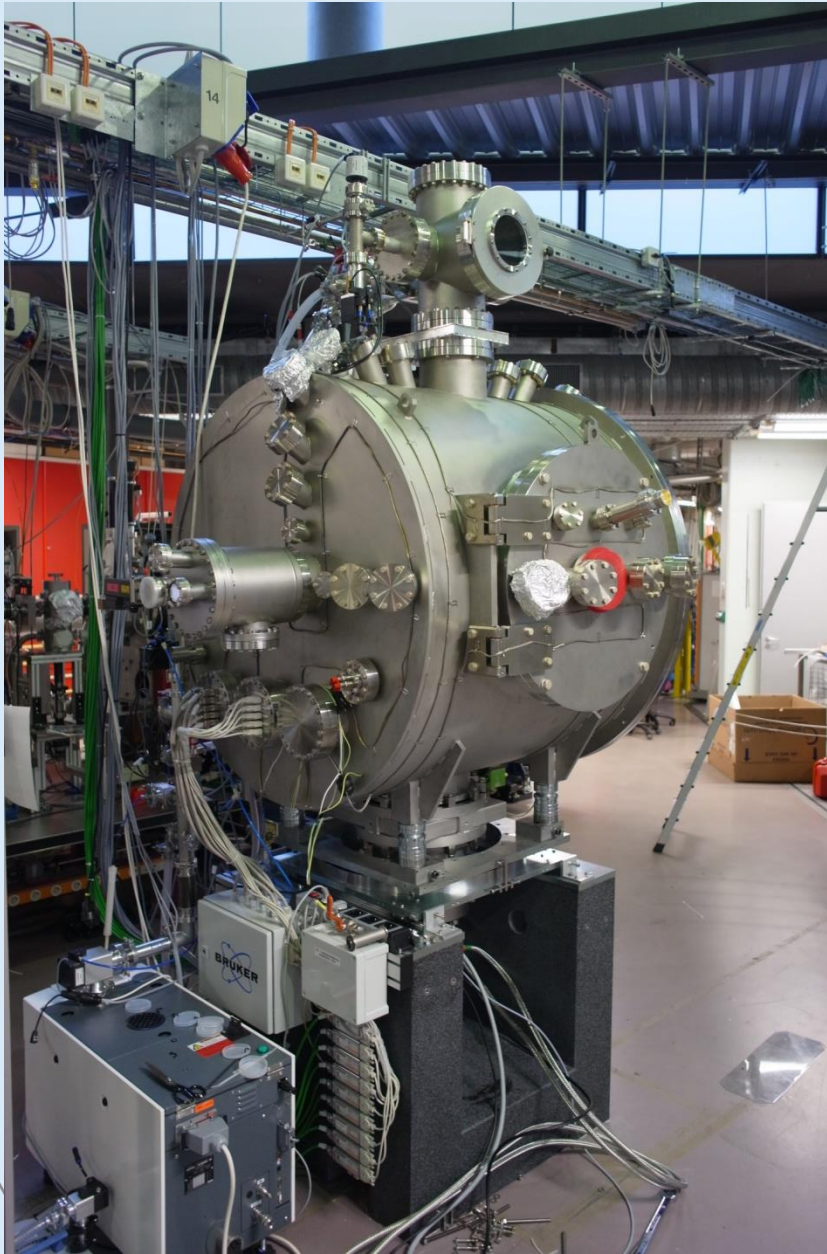


broad band multilayer mirrors for
Brewster-angle reflection

Measurement capabilities of EUV Ellipsometer

incident polarization:	linear
plane of reflection:	arbitrarily oriented
reflected radiation:	linear polarization analyzer
spectral range: (soft X-ray beamline)	1 nm to 25 nm

Installation at soft X-ray beamline



The EUV scatterometer
under installation at the
BESSY soft X-ray Radiometry beamline

Conclusions

PTB operates beamlines from the hard X-ray to THz spectral regime at its SR-laboratories at BESSY II and the MLS

Detector calibration in the full spectral range is based on cryogenic radiometers
Calibrations of customer devices are provided

PTB addresses polarization resolved measurements with

New reflectometer	mechanics without lubrication 2 full range sample rotations full $\frac{1}{4}$ sphere detector movement flexible mounts for CCD detectors for scattered radiation
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EUV beamline	variable setting of linear polarization 98% to 50% sample size up to 650 mm diameter, 50 kg
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Thank you for your attention

